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Soil Attributes on Diversity Indices of Earthworm

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Abstract : Biological diversity is one of the functional attributes of an eco system. The nature of Soil on the diversity indices of earthworms were studied during the year 2010-2012. 168 study fields include eight stations of Theni district such as Periyakulam (S1), Theni (S2), Andipatti (S3), Bodinaykkanur (S4), Chinnamanur (S5), Uttamapalayam (S6), Kambam (S7), and Myladumparai (S8) were selected for the current investigation. 52 species of earthworms were found in various ecosystems of all the 8 stations. Soils of the respective study areas were analyzed for their physico-chemical parameters such as pH, Ec, N, P, K, Fe, Mn, Zn, and Cu. The nature of soil related to species abundance was also analyzed using regression analysis. It was found that the earthworm species abundance decreases with increase in the level of pH, Zn & cu. In other words they both are inversely proportional to each other. The positive sign of the coefficient of Ec, N, P, K, Fe and Mn indicates that the earthworm species abundance directly depends upon the foresaid parameters. Biodiversity of Earthworm species were studied by Shannon wiener and evenness index and was found to be greater in station 7 (Kambam).

Key words : Earthworm species, N, P, K, species abundance and Shannon index.

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1. Introduction

Biodiversity or Biological diversity refers to the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species and of ecosystems. The credit for popularizing this word goes to E.O.Wilson who is often called the "father of Biodiversity" (Arvind Singh., 2010). Earthworms are scientifically classified as animals belonging to the order Oligochaeta, class Chaetopoda, phylum Annelida. In this phylum there are about 1,800 species of earthworms grouped into five families and distributed all over the world. The most common worms in North America, Europe, and Western Asia belong to the family Lumbricidae, which has about 220 species.

Earthworms occur in diverse habitats. Generally they are in top 30-40cm layer of soil which is moist and plenty of organic matter. Earthworms are omnivores they mostly derive nutrition from dead organic matter. They consume soil organic matter and convert it into humus within a short period of time and thereby increase the soil fertility. Within 24 hours they can pass soil almost equivalent to their own weight through the alimentary canal. In temperate climate, the most common vermicomposting worms are Eisenia foetida and Eudrilus eugeniae. For Indian conditions Perionyx excavates is being recommended (Divya, 2001).Species number and ecological categories (e.g. epigeic, endogeic and anecic) are favoured by Paoletti (1999) as key indication parameters in agro ecosystems. In India, studies on the ecology of earthworms are fragmentary and insufficient (Ganihar, S.R., 1996, Chaudhuri, P.S. and G. Bhattacharjee, 1999).

Although several surveys exist in Australia that determine the species distribution of earthworms in agricultural and urban land (Mele et al., 1993), very few have attempted to quantify species abundance. Baker et al. (1992) attempted to relate species abundance to a suite of soil physical and chemical parameters, while other studies have attempted to related dominant earthworm species to a range of soil and agronomic conditions (Buckerfield et al., 1997) or to aspects of soil structural stability (Ketterings et al., 1997).

In general, the greater the intensity and frequency of disturbance, the lower the population density or biomass of earthworms (Hendrix and Edwards 2004).Measures of the size and activity of soil biota, e.g. abundance, diversity and ecological composition of earthworm communities have considerable potential as early indicators of soil degradation or improvement (Haynes and Tregurtha 1999; Seppet al 2005). Number of species and ecological categories are favored by Paoletti (1999) as key indication parameters in agro-ecosystems.

Soil moisture has a major influence on earthworm abundance and diversity, other soil properties such as texture, pH and organic matter content may be important (Edwards and Bohlen, 1996). Earthworms are sometimes more abundant in areas with higher soil organic carbon content (Nuutinen et al., 2001), but not in all studies (Whalen, 2004; Rossi et al. 2006). The activity of the soil microbial community is also important, and was correlated positively with the presence of more sensitive earthworm species in agro ecosystems (Ivask et al., 2008).The recent focus on earthworms as practical indicators of sustainable agricultural management (Lobry de Bruyn, 1997) has highlighted basic knowledge gaps in terms of what earthworms are and what physical, chemical and agricultural management factors influence their distribution and abundance. Knowledge on the ecological appropriateness of species encountered will aid in the selection of species to supplement existing populations.

This study is mainly focused on the earthworm abundance in Theni district and the influence of various physico-chemical parameters on the population dynamics of earthworms. The aim of the research was to study the abundance of earthworm communities in 8 stations of Theni district in relation to the nature of the soils. The specific objectives of the study were to: (1) Determine the abundance and distribution of earthworms, (2) Relate overall and species abundance of earthworms to a range of standard soil.

2. Materials and Methods

2.1 Study Area

Theni is one of the South western districts of Tamilnadu State. It is bounded on the north by Dindigul district, on the east by Madurai district, on the south by portions of Virudhunagar district and Idukki district of Kerala State and on the west by Idukki (Kerala). The district lies between 90 53' and 100 22' north latitude and 770 17' and 770 67' east longitude. The general geographical information of the district is hill area. Vaigai River is flowing in the district and it will normally be dry during the summer season. The total geographical area of the district is 3076.30 Sq. Km. In Theni district eight stations of agricultural areas were selected for the study (Figure 1). These eight stations are covered by different types of habitats.

Sample Collection

In the present Investigation, the work was carried out during 2010–2012. Eight stations (blocks) were chosen for the Collection of Earthworms in Theni district - Periyakulam (S_1), Theni (S_2), Bodinaykkanur (S_3), Andipatti (S_4), Chinnamanur (S_5), Uttamapalaiyam (S_6), Kambam (S_7), and Myladumparai (S_8) (Fig 1). Three fields each were selected and studied from seven spots of eight stations such as banana field, coconut field, sugarcane field, paddy field, vegetable field, floral garden. The database of earthworms of 168 study fields with various soil types was used to compare the results.

Live earthworm specimens were collected from the soil litter and root layers by following the procedure of Omodeo et al. (2003). After counting, they were preserved and sent for identification (Julka, J.M. and R. Paliwal, 1993).

2.3 Analysis of Physico-chemical Parameters

The soil samples collected were numbered and tested for the analysis of Physico-chemical Parameters such as pH, electrical conductivity (EC), macronutrient includes N,P,K and micro nutrients - Fe, Mn, Zn, Cu. Soil pH and EC were measured using soil and distilled water in the ratio of 1:5 suspension in Systronic pH meter and conductivity bridge respectively. The total nitrogen content was analysed by micro-kjeldhal method. Soluble phosphorus concentration (by lactate method) and the concentration of potassium (by flame photometer). Micro nutrients are analysed by atomic absorption spectro - photo meter.

2.4 Statistical Analysis

Regression analysis (SPSS version 17.0) was used to evaluate the relationship between earthworm abundance and soil physicochemical parameter.

3. Result and Discussion

The identified earthworm species are Celeriella punctata, Celeriella ditheca, Celeriella kempi, Celeriella quadripapillata, Celeriella duodecimalis, Celeriella bursata, Celeriella regularis, Drawida parva, Drawida mathai, Drawida ramnadana, Drawida annandalei, Drawida grandis, Drawida rubra, Drawida.sp, Octochaetona thurstoni, Octochaetona serrata, Octochaetona surensis, Octochaetona pattoni, Octochaetona sp, Glyphidrilus tuberosus, Gllyphidrilus annandalei, Glyphidrilus sp, Argilophilus rallus, Argilophilus aquatilis, Argilophilus indicus, Ocnerodrilus accidentalis, Ocnerodrilus orientalis, Lemnoscolelx sp, Lemnoscolex scutarius, Eisenia foetida, Eisenia sp, Lampito maurutii, Lampito marianae, Perionyx sp, Perionyx sansibaricus, Allonais paraguayensis, Allonais sp, Priodochaeta sp, Priodochaeta pellucida, Hoplochaetella stuarti, Hoplochaetella sp, Dichogaster bolaui, Dichogaster sp, Dichogaster modiglianii, Polypheretima elongate, Notoscolex palniensis, Eudrilus eugineae, Pontodrilus sp, Raamiella sp, Moniligaster perrieri, Tubifex tubifex, Spargnophilus eiseni (Table 1) (Figure 2). A community including more sensitive species indicates more suitable ecological or agricultural factors for habitat (Ivask, Kuu, 2005). The unequal distribution of precipitation in 2003–2004 (Keskkonnaülevaade, 2005) was the reason for highest abundance of earthworms in the South and East of Estonia, in the region where pseudopodzolic soils mostly are distributed.

The nature of soil from which the earthworms collected was clay, loamy, sandy clay, clay loamy. They were analyzed for physico - chemical parameters such as Electrical conductivity, pH, Nitrogen, phosphorus, Potassium, Iron, Manganese, Zinc and Copper, and their mean values and standard deviation were calculated. For all the species investigated the sign of coefficient of pH, Zn, Cu were negative and this observation indicates that the earthworm species abundance indirectly depends on these three parameters i.e. with increase of pH, Zn & Cu the earthworm species abundance decreases. The positive sign of the coefficient of Ec, N, P, K, Fe and Mn indicates that the earthworm species abundance directly depends upon these parameters.

It was found that among all the species of earthworms listed, Lampito maurutii is the only species available in maximum number of habitats (18 habitats).The other species and their availability are listed as below: Celeriella punctata (9 habitats), Celeriella ditheca (9 habitats), Octochaetona surensis (7 habitats), Eisenia sp (6 habitats), Perionyx sansibaricus (7 habitats). The low earthworm diversity observed is consistent with other studies on invertebrate ecology in urban areas (Paul and Meyer, 2001). According to Paoletti (1999) and Curry et al. (2002), earthworm populations in cultivated land are generally lower than those found in undisturbed habitats. Agricultural activities such as ploughing, several tillage operations, fertilizing and application of chemical pesticides have dramatical effect on invertebrate animals.

Any management practices applied to soil are likely to have some (positive or negative) effects on earthworm abundance and diversity. These effects are primarily the result of changes in soil temperature, soil moisture and organic matter quantity or quality (Hendrix and Edwards, 2004).

The relative abundance of species i.e., the apportionment of individuals among the species is an important component of the diversity index. All the habitats of species were studied at different locations (Table 1), the regression between the species abundance and physicochemical parameters were calculated. The sign of coefficient of pH, Zn, Cu were found to be negative for all the species investigated and this observation indicates that the earthworm species abundance indirectly depends on these three parameters i.e. the earthworm species abundance decreases with increase of pH, Zn & Cu. The positive sign of the coefficient of Ec, N, P, K, Fe and Mn indicates that the earthworm species abundance directly depends upon these parameters. The abundance of earthworms may increase due to some agricultural activities like liming, organic fertilizing etc. (Kõlli, Lemetti, 1999). Lavelle and Spain (2001) admit that the regional abundance of earthworms and the relative importance of the different ecological categories are determined by large scale climatic factors (mainly temperature and rainfall) as well as by their phylogenetic and bio geographical histories together with regional parameters such as vegetation type and soil characteristics. In the present study also the percentage contribution of nitrogen to earthworm population was high and earlier reports on the qualitative dependence of earthworm population on soil nitrogen content support the same (karmegem & Daniel 2000b). According to Hole et al (2005) the evidence from comparative studies under arable regimes indicates a general trend for higher earthworm abundance under organic management.

The species diversity, richness and equitability indices were analysed following the Shannon-Wiener index (H') (Shannon C.E and Weaver W, 1949) and Evenness index (E) (Pielou E.C., 1975). Analysis of data revealed that maximum species diversity and richness in terms of Shannon-Wiener index (H') was found in Station 7 (3.496) and minimum at station 5 (0.892). The Value of Evenness (E) (1.148) and Shannon index was found to be high in station 7 (Table 2). Shannon's index (H') combines species richness and species evenness components as one overall index of diversity. Higher values of these indices indicate the greater species diversity. It is so obvious that the suitable physicochemical factors and crop rotation compared to other sites enhance the values of species richness at station 7. This is in concordance with the work of Padmavathi M., 2013 that Differences in various chemical properties of soil viz. pH, organic matter, nitrogen, phosphorus, potassium, and calcium are the factors which are highly responsible for the distribution and abundance of earthworms in the soil of an area.

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Earthworm Family/species	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station8
MEGASCOLECIDAE *Celeriella punctata*	Sugarcane, Paddy	Banana	-	Pepper, Sugarcane	-	Grapes	Beans, Sugarcane, Mango	-
Celeriella ditheca	sorghum	maize	Coconut, Beans	-	Grapes	Beans & chilly intercrop, Grapes	Marigold	Marigold
Celeriella kempi	sugarcane	-	-	-		-	-	-
Celeriella duodecimalis	banana	-	-	-	-	-	-	-
Celeriella quadripapillata	sugarcane	-	Maize	-	Maize	-	-	-
Celeriella bursata	Coconut	-	-	-	-	-	-	Sapota, Coconut, Sapota
Celeriella regularis	maize	Marigold, Beans	-	-	Beans, Paddy	Banana	Maize	Drumstick
Argilophilus rallus	paddy	-	-	Cauliflower	-	Grapes	Banana, Drumstick	-
Argilophilus aquatilis	-	-	Jasmine	-	-	-	-	-
Argilophilus indicus	-	-	Hyacinth bean	-	-	-	-	-
Notoscolex palniensis	paddy	-	-	drumstick	Grapes	-	Drumstick	-
Lemnoscolex scutarius	Coconut	-	Maize	-	-	Coconut Beans	Paddy	-
Lemnoscolex sp	Red gram & chilly intercrop	-	-	-	-	-	-	-
Polypheretima elongate	-	-	beans	-	Grapes	-	-	-
Lampito mauritii	-	Sugarcane, Coconut, marigold	Brinjal, Drumstick	maize	Silk cotton, Cotton, Paddy, Grapes, Coriander, Grapes	-	-	Beans, Drumstick, Maize, Cabbage, Beans
Lampito marianae	-	-	-	-	-	-	Onion	-
Perionyx sansibaricus	-	coconut	sugarcane	-	chilly	Drumstick	sugarcane	Coconut, Coconut
Perionyx sp	-	-	-	-	Grapes	-	-	-
Priodochaeta sp	-	-	Banana	-	-	-	-	-
Priodochaeta pellucida	-	-	-	Paddy	-	-	-	-
Pontodrilus sp	-	-	-	Cowpea	-	-	Paddy	-
OCTOCHAETIDAE *Octochaetona surensis*	Coconut, Drumstick	-	-	Banana, coffee	-	Beans	Grapes, Beans	-
Octochaetona thurstoni	-	Frangipani flower	-	-	-	-	-	-
Octochaetona pattoni	-	Onion	Maize Tomato	-	-	-	-	-
Octochaetona serata	-	-	-	sugarcane	-	coconut	-	Drumstick
	-	-	Banana	Cotton	-	Banana	-	coconut

Octochaetona sp								
Hoplochaetella stuarti	-	-	-	Red gram	-	Paddy	coconut	-
Hoplo chaetella sp	-	Paddy	-	-	-	-	-	coconut
Dichogaster bolaui	-	Banana	-	-	-	-	-	-
Dichogaster sp	-	-	-	Maize	Paddy	Frangipani flower	coconut	Drumstick, coconut
Dichogaster modiglianii	-	-	-	-	-	-	-	Maize
MONILIGASTRIDAE *Drawida annandalei*	Sugarcane	-	-	-	-	-	-	-
Drawida mathai	paddy	Rose, Jasmine	Beans	-	-	sugarcane	Grapes	-
Drawida ramnadana	Coconut, Banana	-	-	-	-	Marigold, Grapes	-	-
Drawida grandis	-	-	-	Cabbage	-	Beans	Grapes	-
Drawida rubra	-	-	-	Paddy	-	-	Grapes	-
Drawida parva	-	-	-	Paddy	-	-	paddy	-
Drawida sp	-	oleander	-	-	Grapes	-	-	Onion
Moniligaster perrieri	-	-	Tomato	-	-	-	-	-
OCNERODRILIDAE *Ocnerodrilus orientalis*	-	Mullai (kind of jasmine)	-	-	-	-	-	-
Ocnerodrilus accidentalis	-	-	-	Paddy	-	-	-	-
NAIDIDAE *Allonais paraguayensis*	-	-	-	-	-	Paddy	-	-
Allonais sp	-	-	-	-	-	-	-	Gooseberry
ALMIDAE *Glyphidrilus annandalei*	Mango	-	-	-	-	-	-	-
Glyphidrilus tuberosus	Beans, Cassandra	-	Hyacinth bean	-	Coconut	Papaya	-	-
Glyphidrilus sp	-	Oleander	-	Betel-leaf	-	-	-	Drumstick
LUMBRICIDAE *Eisenia sp*	-	Banana, Marigold	Sugarcane, Sugarcane	-	Coconut, Banana	-	-	-
Eisenia foetida	-	-	Coconut	-	-	Maize, Coriander	-	-
Spargnophilus eiseni	-	-	-	coconut	-	-	-	-
EUDRILIDAE *Eudrillus eugineae*	-	Cassandra , Coconut	-	Cotton, Sugarcane	Grapes	-	Coconut	-
ACANTHODRILIDAE *Ramiella species*	-	-	Maize	-	-	-	-	-
TUBIFICIDAE *Tubifex tubifex*	-	-	-	-	Beans	-	-	-

Table : 1 Area wise occurrence of earthworm species in different habitats

Stations	Shannon Diversity Index	Evenness index
Station 1	2.794	0.918
Station 2	2.634	0.865
Station 3	2.794	0.918
Station 4	2.716	0.892
Station 5	0.892	0.793
Station 6	2.716	0.892
Station 7	**3.496**	**1.148**
Station 8	2.304	0.757

Table. 2 Earthworm species abundance calculated by Shannon and Evenness indices

Figure 1. Earthworm survey sites in Theni district.

TamilNadu Map Theni District Map

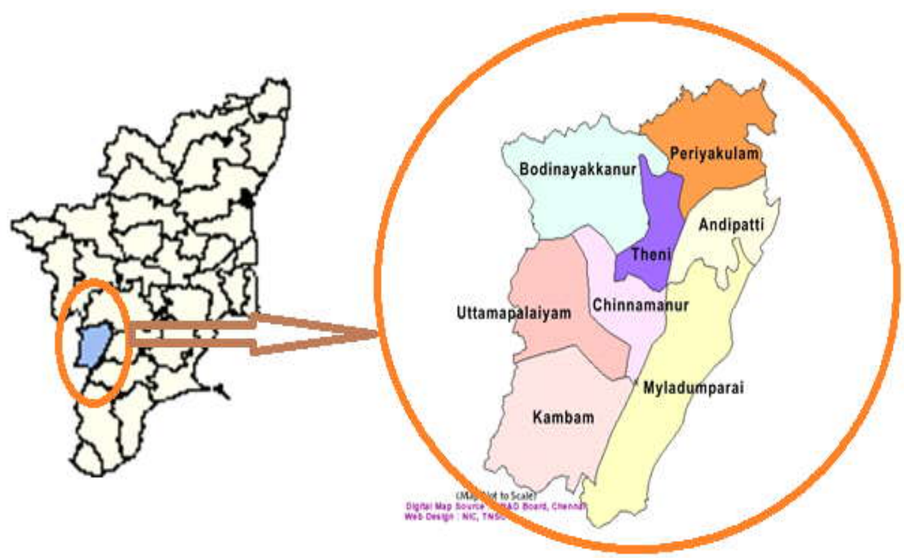

Figure 2. Identified earthworm species